THE REPRODUCTIVE BIOLOGY OF *CARASOBARBUS LUTEUS* (PISCES, CYPRINIDAE) IN AL-HAMMAR MARSH, IRAQ

by

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RÉSUMÉ. Les auteurs étudient la stratégie de la reproduction chez *Carasobarbus luteus* et définissent un cycle à 9 stades. Le diamètre des ovocytes est étudié pour chaque stade et la fécondité est exprimée en fonction de la longueur, du poids et de l'âge des poissons ainsi que du poids des gonades. Il est montré que l'âge à la première maturité sexuelle est fonction de la taille maximum atteinte par l'espèce et que l'ensemble du cycle dépend d'un certain nombre de facteurs externes tels que température et abondance de la nourriture.

ABSTRACT. The authors describe the reproduction cycle of *Carasobarbus luteus* and define 9 phases in that cycle. The ovocyte diameter is studied for each phase and the fecundity is expressed as a function of the body length, body weight and age of fish, and of the gonad weight. It is demonstrated that the age at the first maturity depends on the maximum size attained by the species and that the overall cycle is under the control of some external factors such as temperature and availability of food.

Key-words: Cyprinidae, Carasobarbus luteus, Reproductive cycle, Fecundity, Iraq.

Carasobarbus luteus (= Barbus luteus) is one of the most important commercial fish in Iraq particularly in the South where the Marshes represent the main biotopes for this species. Few studies have been published on the different biological aspects of this species. The growth of *C. luteus* in Tharthar reservoir have been studied by Ahmed (1982) and in Al-Hammar Marsh by Al-Mukhtar (1982), the food has also been studied by Al-Mukhtar (1982). Testicular and ovarian activities of *C. luteus* from Shatt Al-Arab river have been studied by Bhatti and Al-Daham (1978) and Al-Daham and Bhatti (1979) respectively.

The present study carried out in 1980 aimed to provide adequate information on the different aspects of the reproductive biology of *C. luteus.*

MATERIALS AND METHODS

Monthly samples of *C. luteus* were obtained from Al-Hammar marsh, south of Iraq (Fig. 1) during the period December 1980 to November 1981 using gill nets of different mesh size. Nets were set before dusk and raised at dawn. The total number of fish examined was 515. Fish were kept immediately in ice untill taken

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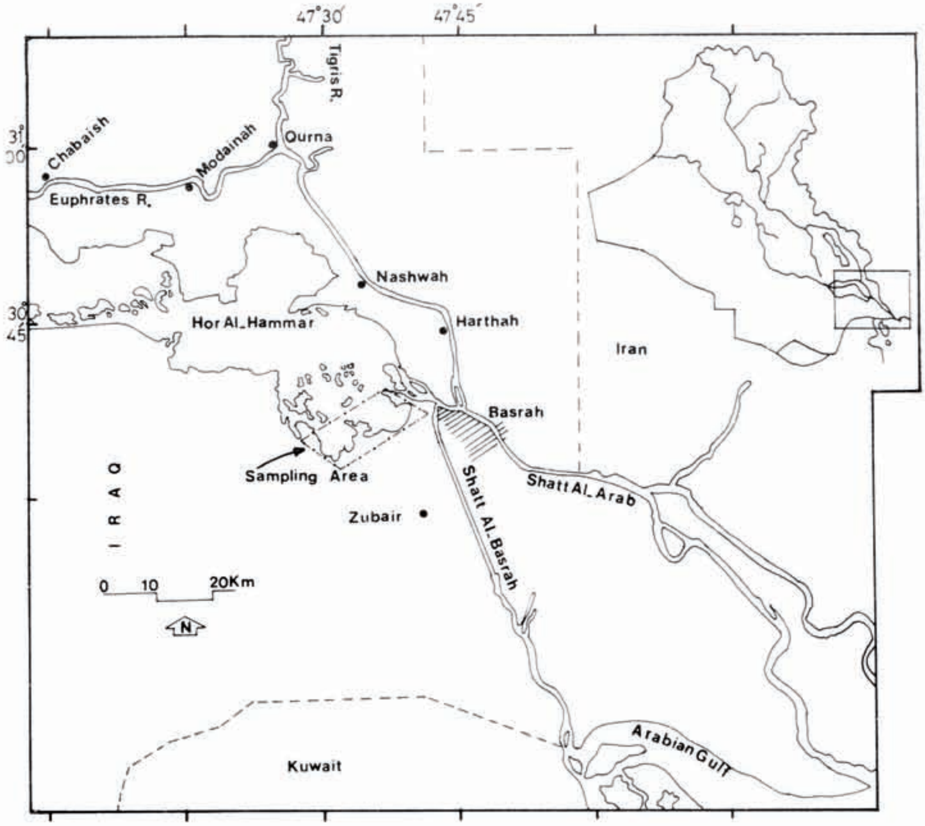

Fig. 1. – Map of the area sampled.

to the laboratory. The following characters were taken for each individual fish : total length, total weight, sex, gonad weight, and about ten scales were also taken from each fish to determine the age. For female fish, ovaries were preserved in 10 % formalin for measuring ovocyte diameter. Ovocyte samples were taken from three positions, upper, middle and lower part of the ovary. Measurements were made for 100-300 ovocytes from each ovary using eye piece micrometer. Ripe ovaries were placed in Gilson's fluid (modified by Simpson 1958) for fecundity estimation, containers were periodically shaken to help in releasing the ovocytes and dissolving the tissue. Undissolved tissue were removed using forceps under the dissecting microscope. Fluid containing free eggs was then filtered in Buchner funnel, washed with water and filtered again, then transferred to a previously weighed petridish and kept exposed.

Weight of the whole eggs was taken every five minutes; when weight became constant four subsamples of fixed weight (0.01 g) were taken and the number of eggs in each subsample was counted under the microscope. The mean number of eggs in these four subsamples was determined. Fecundity was then calculated, using the following equation :

$$F = \frac{\text{number of eggs in subsample}}{\text{weight of subsample}} \times \begin{array}{l}\text{weight of eggs}\\ \text{at sampling time}\end{array}$$

Relative fecundity or number of eggs per gram of body weight was also calculated. To trace the change in fish condition, somatic condition factor was calculated using the following equation :

$$K = \frac{W - W_g}{L^3}$$

where W = body weight, W_g = gonad weight, and

L = total length.

RESULTS

The maturity cycle

General morphology and histological structure of the testis and ovary of *C. luteus* have been mentioned by Bhatti and Al-Daham (1978) and Al-Daham and Bhatti (1979) respectively. They defined five distinct cyclical changes in the ovary and testis, namely : resting stage, preparatory stage, pre-spawning stage, spawning stage and post-spawning stage. It was found, however that it is possible to extend the stages into nine following the pattern given by Macer (1974) for the horse mackerel *Trachurus trachurus*. The description of the nine maturity stages in *C. luteus* is given in Table I.

The seasonal occurrence of the maturity stages

The proportion of fish in the different maturity stages was calculated in each monthly samples and the data for females and males are shown in Fig. 2. Maturing eggs were found during March, April and May. Spawning started in April and after July no female fish was still in the partially spent stage. Development of sperms clearly coincides with that of the eggs.

Growth of gonads

The gonad weight as a percentage of body weight (gonado-somatic index) undergoes changes during maturation cycle. This change is shown in Fig. 3. It is clear that the process of gaining weight is faster and less long in females than males leading to a proportionally much heavier ovaries. Moreover it is started in stage 3 in the ovary and reached the peak during the stage 4, 5 and 6 . The seasonal changes in mean weight per sample are shown in Fig. 3. In both males and females, gonad weight reaches a peak in April then weight decrease during May after which the weight falls rapidly indicated that the release of ovocyte and spermatozoa is somewhat lengthy.

Table I : Description of the maturity stages of *C. luteus*

Maturity stage		Description	
		Ovary	Testis
1.	Virgin	Ribbon or thread like, translucent, ovocyte not distinguished, dark spots on the dorsal side of the ovary, thick membrane.	Flattened, unlobed, threadlike, hardly distinguished by naked eye, translucent, colorless.
2.	Developing Virgin	Ribbon like, Semi-translucent, yellowish-white, lobes start appearing. Ovocyte not distinguished, dark spots on the dorsal side, less than one third of length of body cavity.	Thread like, thin, about half of length of body cavity, gray, translucent.
3.	Developing (early)	One third of body cavity. Ovocyte visible to nacked eye producing spickeled appearance, gray, not translucent.	Ribbon like pinkish white, not translucent, half of length of body cavity.
4.	Developing (later)	Half to one third of body cavity, ovocyte visible, yellow to orange, few translucent, triangle cross section filling the gap between the two lobes of the air sac.	Firm, yellowish white, not translucent, lobed, one third of length of body cavity.
5.	Ripe or maturing	Two third of body cavity, firm, orange, ovocyte transparent, membrane very thin, lobed.	Firm, flattened, yellowish white, two third of body cavity.
6.	Running	Filling body cavity, orange in color, ovocyte large transparent run from vent on slight pressure.	Firm, flattened, white, two third of body cavity, filling the gap between the two lobes of the air sac. Milt run from vent on slight pressure.
7.	Partially spent	Spickeled in appearance, dull yellow, partially opaque and transparent ovocyte.	Flattened, pinkish white, edges transparent, wrinkled, lobed two third of body cavity.
8.	Spent	Flaccid, adhearing to air bladder as an empty sac, dark red, few tiny opaque ovocyte present.	Dull reddish white, adhearing to the air bladder, nearly empty.
9.	Resting	Ovary white, semi-transparent firm than stage 8, few spots present, veined, ovocyte colorless very small in size.	White, one third of body cavity, ribbon like with yellow spots.

Somatic condition factor

The ratio of body weight (excluding gonad) in grams to the cube of the total length in centimeter are shown in Fig. 4 both for males and females in the different maturity stages (Fig. 4a) and seasonally (Fig. 4b). Somatic condition factor showed their maximum values in both males and females during the stages 1 (virgin) and 9 (resting). In addition, the general trend indicates a gradual decrease of the somatic condition factor toward stage 8 (spent), this however was not so marked in the seasonal changes of the somatic condition factor (Fig. 4b).

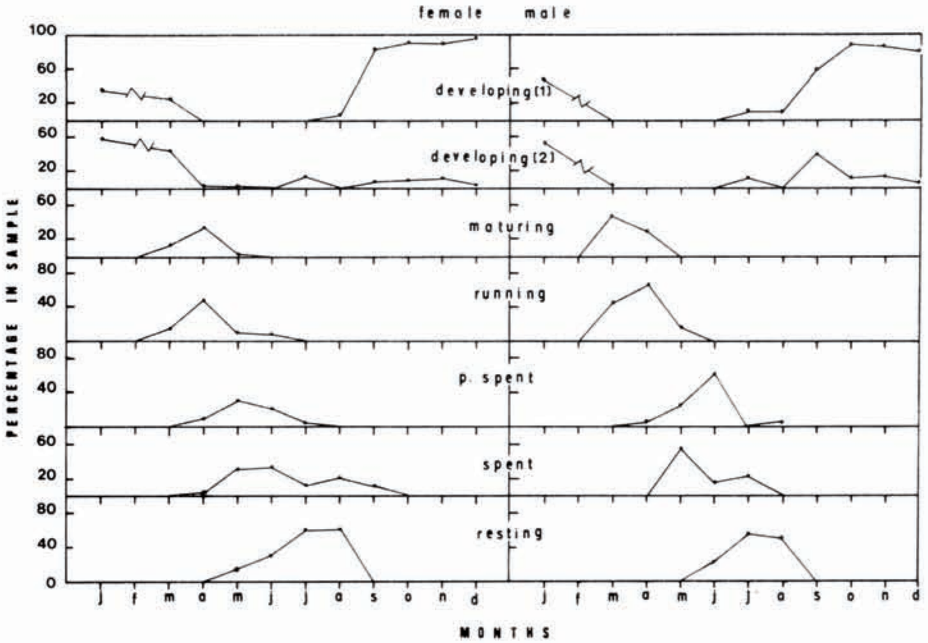

Fig. 2. – Seasonal variations in the proportion of maturity stages in female and male *C. luteus.*

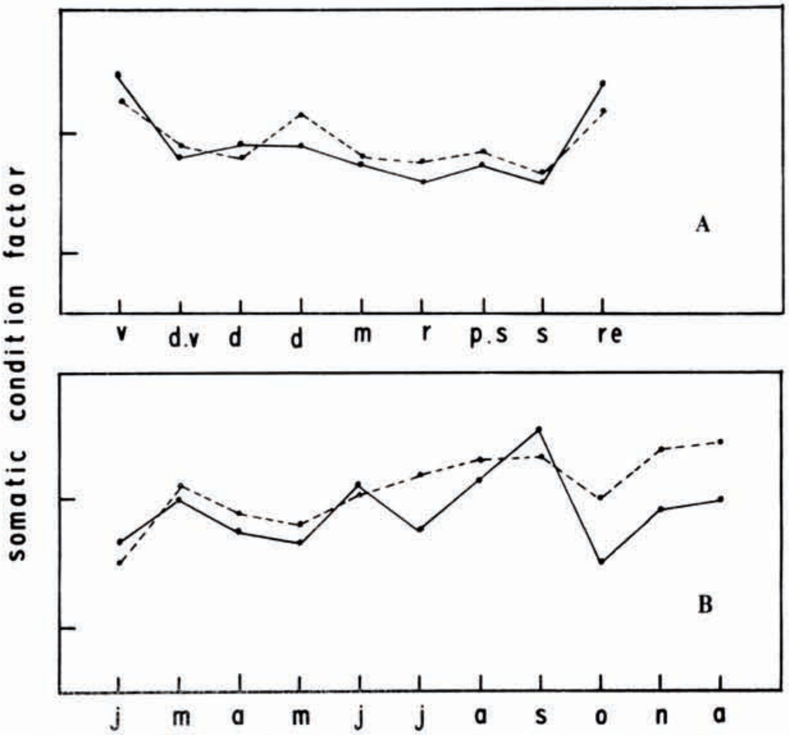

Fig. 3. – Somatic condition factor in the different maturity stages (a) and the different months (b) both for females (– – –) and males (——) *C. luteus.*

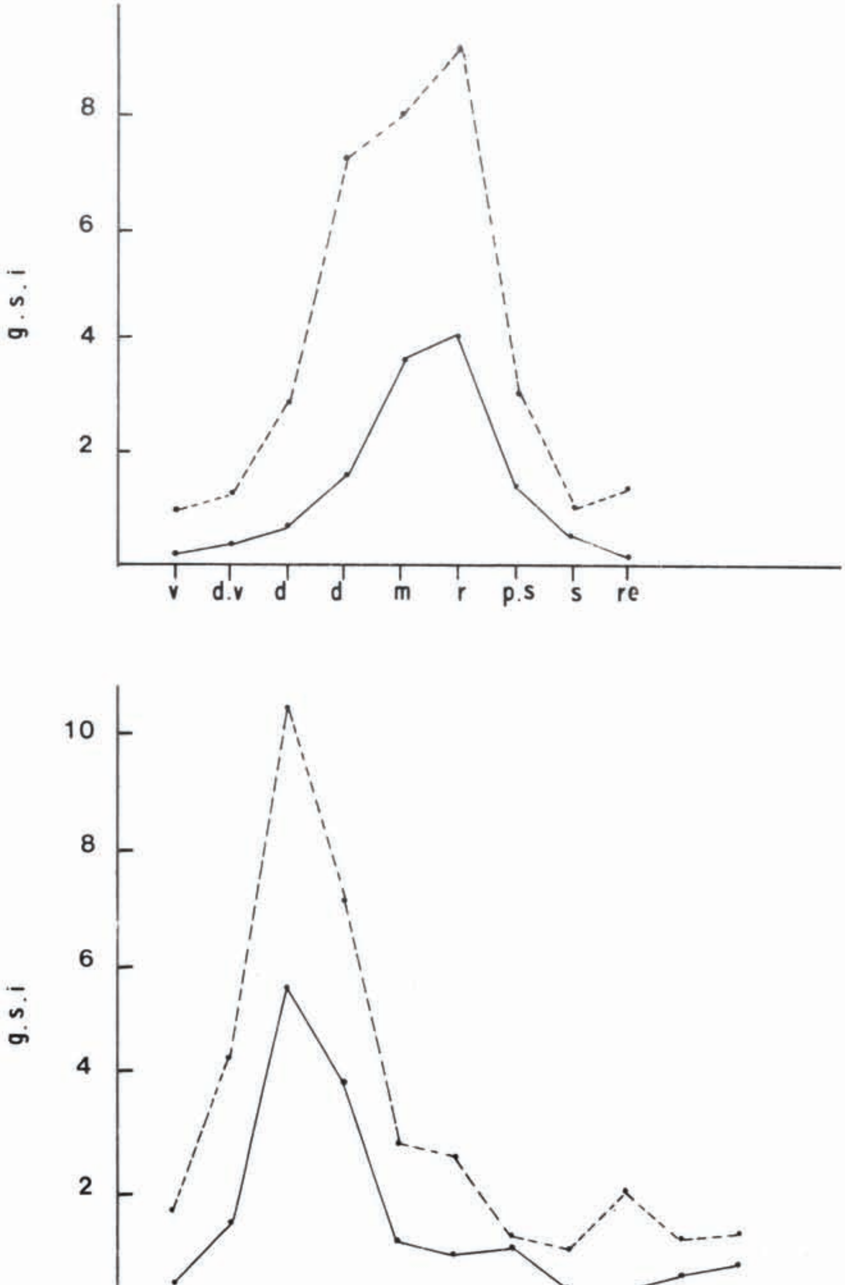

Fig. 4. – Gonadosomatic index in the different maturity stages (a) and the different months (b) for both females (– – –) and males (——) *C. luteus.*

Table II : Percentage of ovocyte diameter in each maturity stage.

Ovocyte diameter		0.14	0.29	0.43	0.57	0.86	1.00	1.14	1.29	1.43	1.57	1.70	1.86	
Stages	**Virgin**	80.0	20.0											
	Developing virgin	50.0	30.0	20.0										
	Developing (early)	50.0	16.0	8.6	8.3	6.4	4.8	4.1	1.3					
	Developing (later)	37.0	13.1	7.2	9.3	9.2	8.8	6.7	4.5	4.2				
	Ripe or maturing	39.9	17.6	4.9	5.6	5.3	5.9	4.9	3.7	3.4	3.2	4.2	0.8	0.08
	Running	31.4	17.4	4.2	6.4	7.1	6.9	5.8	6.2	4.0	4.0	5.1	1.4	0.1
	Partially spent	59.1	12.1	4.3	7.1	6.6	6.4	4.4						
	Spent	74.1	20.2	3.3	1.5	0.7	0.2							
	Resting	75.0	19.7	2.8	2.0	0.4								

Ovocyte diameter

Percentages of different ova size in each maturity stage are given in Table II. It is clear from this table that ova increase in size when maturation cycle proceeds during stage 1; two sizes were represented, 0.14 mm (80 %) and 0.29 mm (20 %), a third size, 0.43 mm (20 %) appearing during stage 2 and in stage 3 some of the ova (1.3 %) reaching a diameter of 1.29 mm. In stage 4, 4.2 % of the ovocytes had a diameter of 1.43 mm; during this stage the percentage of ova bigger than 0.43 mm, were also more than in stage 3. In stage 5, 0.08 % of the ovocytes reached 1.86 mm in diameter, percentages of other different ovocyte diameters were however more or less the same. In stage 6, the percentage of ovocytes with the diameter 1.86 were increased to 0.1 %. In stage 7 ova diameter measuring more than 1.14 mm was not noticed, more than 50 % of the ovocytes had 0.14 mm diameter. Percentage of other measurements were more or less the same ranging between 4.4 and 12.1. In stage 8 few ovocytes measured 1.00 mm, while most of the eggs in this stage (74.1 %) and the following stage (75.0 %) were measuring 0.14 mm.

Length and age at first maturity

The minimum length recorded for a mature female was 112 mm and for a mature male was 122 mm. In length group ranging from 110 - 120 mm, the percentage of mature fish (male and female) was 90 %. Among age group 1^+, 9.4 % of the females (three individuals) were mature while all males examined in this age group were mature.

Fecundity

Only fish with well developed ovaries were used in determining the fecundity. Seventeen individuals were examined for this purpose. Details on the fecundity are given in Table III. This table indicates that the number of eggs produced per fish varied widely within nearly the same length and between individuals of the same age group. Specimens examined ranged in lengths from 127 to 260 mm, and in weight from 28.68 to 259.14 g, the eggs produced per female ranged from 1729 to 38433. Fecundity was related here to different parameters of the fish, namely length (L), weight (W), age (A) and gonad weight (Wg). The equations obtained were as follows :

Fecundity-Length relation

$$\text{Log } F = -2.45 + 2.8 \text{ Log } L$$
$$\text{or } F = 0.0358\, L^{2.31} \qquad (r = 0.83)$$

Fecundity-Weight relation

$$F = -20.53 + 108.16\, W \qquad (r = 0.87)$$

Fecundity-Age relation

$$\text{Log } F = 3.55 + 1.24 \text{ Log } A$$
$$\text{or } F = 3521.5\, A^{1.24} \qquad (r = 0.86)$$

Fecundity-Gonad weight relation

$$\text{Log } F = 3.092 + 1.01 \text{ Log } W_g$$
$$\text{or } F = 1237.31\, W_g^{\,1.01} \qquad (r = 0.80)$$

In all the relations, the coefficient of correlation (r) was significant at 0.01 level. The highest (r) were with weight, while the lowest were with weight of the gonads. Relative fecundities are given in Table III, the coefficient of correlation of the relative fecundity with length, weight, age and gonad weight was − 0.11, − 0.11, − 0.34 and 0.06 respectively. It was not significant at 0.05 level.

Table III : Details on the fecundity of *C. luteus.*

Total length (mm)	Weight (g)	Age	Gonad Weight (g)	Ovocyte Weight (g)	Standard deviation	Absolute fecundity	Relative fecundity
127	28.68	I	1.33	0.50	11.5	1729	60.3
128	29.67	I	4.32	1.20	19.9	3429	115.6
135	25.97	I	3.77	0.78	12.2	2204	84.9
139	38.46	I	5.34	1.50	6.7	5066	131.7
140	40.68	I	5.72	1.10	9.0	4892	120.2
160	60.76	I	6.62	1.80	26.8	6296	103.6
175	69.00	II	5.43	2.82	74.7	2117	306.0
178	68.12	Nd*	9.26	1.60	22.6	10632	156.1
183	81.50	II	4.33	2.40	27.9	7365	90.4
200	111.25	II	8.32	1.50	18.9	8186	73.1
208	120.90	III	8.39	1.57	29.6	8812	72.8
211	124.03	II	6.88	1.10	9.0	5892	39.4
232	164.84	III	7.81	1.20	39.7	12390	75.2
246	181.24	III	9.33	1.50	18.5	11531	63.6
250	228.20	Nd	19.73	5.50	16.7	24206	106.1
252	239.03	IV	10.97	4.48	51.8	24745	103.5
260	259.14	VI	22.04	7.10	32.4	38433	148.3

* Nd = age was not determined.

DISCUSSION

The study of the maturity cycle in *C. luteus* showed that all maturity stages could be found in the area studied, indicating that spawning takes place in the same area (Lee, 1972). Males and females followed the same line in their gonad development, this was also recorded by Bhatti and Al-Daham (1978) and Al-Daham and Bhatti (1979) in their studies on the testicular and ovarian activities of the same species. However they divided the maturity cycles into a less specific stages. Atretic degeneration takes place in the spawned ovaries and a stage of partially spent were clear during development; this process was recorded in many other species like *Trachurus trachurus* (Macer, 1974), *Mastacembelus armatus* (Gupta, 1974, 1975) and *Sprattus sprattus* (De Silva, 1973).

Seasonal variations in the occurence of the different maturity stages showed that in one collection from the population, different maturity stages could be found, the percentage of these maturity stages, however, differs in accordance with the spawning time. Reproductive cycle lasted for twelve months and ended in April were the « partially spent » stage were found, the same type of reproductive cycle was recorded for Sprat (*Sprattus sprattus*) by De Silva (1973), and although spawning does not take place at the same time in all females, every female needs twelve months to reach the maturity stage indicating that the species reproduces once a year. Spawning period was long and lasted for four months (April - July). Therefore fish band in this area suggested by the Ministry of Agriculture (15th February to 15th April) is not suitable for this species, since the band ends while the fish are still in their spawning period. The appearance of the « resting stage » during May and the stage « developing » in July indicates that June is the month during which the ovaries prepare themselves for redeveloping. Seasonal variations in gonado-somatic index and condition factor for males and females showed that spring is the spawning season, summer is to regain strength and then during winter and autumn fish prepare for the next reproductive cycle. The low condition factor recorded during the preparation for spawning is an expected result (Brown, 1957, Gupta, 1974, Scott, 1974, Weatherley and Rogers, 1978).

The spawning time of *C. luteus* in Shatt Al-Arab river recorded by Bhatti and Al-Daham (1978) and Al-Daham and Bhatti (1979) were May-July, indicating that *C. luteus* in Al-Hammar marsh spawns earlier and spawning period lasts longer. This difference may be related to the higher temperature of the water in the Marsh as a result of its shallow depth. De Silva (1973) found that higher temperature causes an earlier development of the gonads. Cole (1905) noticed that the carp spawns during April in the southern states and during July in the northern states of America. Malhotra (1966) mentioned that the rise in temperature accompanied by the blooming of the phytoplankton and the whole food chain are factors stimulating the fish to start their spawning.

Size of the ovocytes in the different developmental stages showed that the largest size attained by the ovocytes was during stage 5 (ripe or maturing), i.e. 1.86 mm, that is three times larger than the size recorded by Al-Daham and Bhatti (1979) for the ovocytes of the same species in Shatt Al-Arab river during the prespawning stage. This could be attributed to the food availability or to higher growth rate (Bagenal, 1971, Scott, 1974).

Although no exact length at first maturity was recorded, it is known now, however, that this length is less than 112 mm for females and less than 122 mm for males. Cushing (1968) showed that the length at first maturity increases with the increase of the maximum length attained by fish; length at first maturity of bigger *Barbus* species living in Iraq shows this fact clearly. Al-Hakim *et al.* (1981) found that the females of *Barbus grypus* in Dokan reservoir reached a length of 390 mm at first maturity. Al-Hamid (1972) found that the males of *B. sharpeyi* mature when they are 250 mm in length and the females when they are 280 mm.

The recorded age at first maturity for *C. luteus* (age group I^+) was less than the age recorded for the related *Barbus* species; Al-Hamid (1972) found that in *B. sharpeyi* both sexes reach maturity during the second year of their life; they spawn, however, during their third year (II^+); he also found that *B. grypus* and *B. xanthopterus* attained sexual maturity during their fourth year and spawn during their fifth year (IV^+). Cushing (1968) found that age at first maturity is closely related to the maximum age attained by the fish, those fish living longer have an older age when they mature. *C. luteus* have a shorter life compared with other related species (Ahmed, 1982) which explain their younger age at first maturity. Gupta (1975) found that temperature play an important role in maturity, he found that female common carp, raised in a warm ponds, attain sexual maturity in six months, while wild females mature in fourteen months; Swain (1980) stated that geographical distribution is an important factor in determining the time of maturity.

In addition to the mentioned possible factors for the early sexual maturity of *C. luteus*, over-fishing noticed in this area may also speed the maturity. Kerbs (1978) stated that when mortality rate increases, the individual will reproduce as soon as possible. Nikolsky (1969) claimed that a high rate of growth during early life (which is the case in this species) is an attempt to reach a suitable size for maturity.

Fecundity was related to different parameters of the mother. The correlation coefficient indicates that fecundity have a better relation with weight than other parameters. Bagenal (1978) found that when the weight is closely related to the condition of the fish, fecundity will be correlated to the weight of the fish better than the length, next to the weight comes the age. The low correlation coefficient obtained from the relation of the fecundity with gonad weight is possibly due to the variations in ovocyte size (Scott, 1962).

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